Esophagectomy Surgical Apgar Score May Not Be Associated With Postoperative Morbidity

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This study was performed to investigate the association between the esophagectomy surgical Apgar score (eSAS) and 30-day morbidity after esophagectomy. We retrospectively identified patients who underwent esophagectomy in our facilities database from January 2011 through December 2015. We calculated the eSAS and modified eSAS, which was adjusted for the blood loss volume, according to our patients' data. After estimating the cut-off point of the eSAS using a receiver operating curve, the morbidity rates between the 2 groups were compared using Fisher's exact test. In addition, logistic regression analysis was performed to adjust the results by factors associated with morbidity. In total, 246 patients were included. Of these patients, 144 presented with major morbidity. The optimal cut-off value of the eSAS was 4 points. A total of 145 patients had an eSAS of <4 points, and 89 of them developed morbidity. A total of 101 patients had an eSAS of ≥4 points, and 55 of them developed morbidity. Fisher's exact test showed that an eSAS of <4 points was not significantly associated with morbidity after esophagectomy (*P* = 0.29). The association was improved after modification for the blood loss volume (*P* = 0.004). Multivariable analysis revealed that the modified eSAS and age were significantly associated with morbidity (odds ratio, 0.47 and 1.04, respectively). The validity of the eSAS to predict morbidity after esophagectomy could be low, and the modified blood loss volume may improve the predictive effect.

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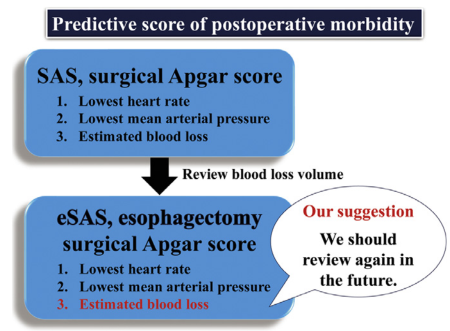
Keywords: Esophagectomy, Esophagectomy surgical Apgar score (eSAS), Morbidity, Estimated blood loss



When using the eSAS, the estimated blood loss should be reassessed.

Central Message

The eSAS was not associated with postoperative morbidity, even with an optimal cut-off value. The modified eSAS, which is adjusted for blood loss volume, was associated with postoperative morbidity.

Perspective Statement

The clinical value of the eSAS remains controversial. The modified eSAS, which is adjusted for blood loss volume, was associated with the postoperative morbidity. The multivariate analysis also showed that the modified eSAS, but not the eSAS, was associated with major morbidity. Future research should focus on estimating the blood loss volume item of the eSAS.

Abbreviations: HR, heart rate; MAP, mean arterial blood pressure; EBL, estimated blood loss; SAS, surgical Apgar score; eSAS, esophagectomy surgical Apgar score; BMI, body mass index; NSQIP, National Surgical Quality Improvement Program; OR, odds ratio; CI, confidence interval

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INTRODUCTION

The surgical Apgar score (SAS)[1] is a prognostic score that predicts postoperative morbidity at the end of surgery. The SAS is a simple score ranging from 0 to 10 points and is calculated from only 3 intraoperative valuables: lowest heart rate (HR), lowest mean arterial blood pressure (MAP), and estimated blood loss (EBL). Although the SAS was initially developed for use with colectomy,[1] its usefulness has been confirmed in many surgical specialties including urological surgery,[2] gynecologic surgery,[3] orthopedic surgery,[4] and neurosurgery.[5]

Janowak et al[6] revised the scoring system for EBL and established the esophagectomy SAS (eSAS) to evaluate the patient's condition after esophagectomy. They reported that the eSAS with a cut-off of 6 points was strongly associated with 30-day morbidity after esophagectomy.

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Although many studies have been performed to evaluate the SAS, only 2 studies have assessed the eSAS. Xing et al[7] evaluated a series of 189 patients and showed that the eSAS with a cut-off of 7 points was predictive, while Stroyer et al[8] assessed a series of 234 patients and found that the eSAS did not predict complications across different cut-off points. Moreover, Stroyer et al[8] changed the eSAS to a “modified eSAS” according to an eSAS calculation formula, which resulted in no prognostic ability. Based on this background, the reliability of the eSAS has remained controversial even in recent years.

The present study was performed to evaluate the association of the eSAS with 30-day major morbidity after esophagectomy using a database of our facility.

METHODS

Study Overview

We conducted a retrospective cohort study of the medical records of all surgical patients with esophageal cancer who visited Shizuoka General Hospital from January 2011 through December 2015. For every enrolled patient, we calculated the eSAS and the modified eSAS, which was adjusted for blood loss point according to our patients’ data. The cut-off points of the scores were then calculated using a receiver operating curve (ROC). Next, the occurrence of 30-day major morbidity after surgery was compared between 2 groups divided by the cut-off score. Logistic regression analysis was also performed to adjust for associated factors.

This study was conducted according to the STROBE checklist[9] and in compliance with the Declaration of Helsinki. The review board of Shizuoka General Hospital approved this study (IRB #SGHIRB2015045).

Patients

We included all patients who underwent elective esophagectomy at Shizuoka General Hospital from January 2011 through December 2015. To match the background of patients in a recent study of the eSAS,[6] we excluded patients who underwent resection for both esophageal cancer and another disease during the same surgical operation. We also excluded patients with an implanted cardiac pacemaker and those who underwent surgery for benign disease.

The recorded patient data were age, sex, height, weight, American Society of Anesthesiologists physical status, smoking history, chemoradiation therapy history, and comorbid disease including pulmonary disease (obstructive or restrictive pulmonary disease), cardiovascular disease (coronary artery disease, congestive heart failure, peripheral vascular disease, or cerebrovascular disease), chronic kidney disease (baseline creatinine level of >1.8 mg/dL or on hemodialysis), and diabetes mellitus.

Intraoperative Data

The surgical approach, surgical technique, surgical time, anesthesia time, EBL, lowest HR, and lowest MAP were recorded. The surgical approach included open esophagectomy (thoracotomy and laparotomy), hybrid esophagectomy (either laparoscopy and thoracotomy or laparotomy and thoracoscopy), and minimally invasive esophagectomy (laparoscopy and thoracoscopy). The surgical technique included transthoracic and transhiatal esophagectomy.

Based on the methodology[10] adopted in the above-mentioned study of the eSAS,[6] the eSAS was calculated from 3 items: the lowest HR, lowest MAP, and EBL. The eSAS was calculated by changing the EBL cut-off points based on quartile values of EBL in the previous authors’ patient cohort.[6] Therefore, we applied the EBL of our own facility to the eSAS formula and created a “modified eSAS” (Table 1). The lowest HR and lowest MAP used in the modified eSAS were not different from those of the eSAS (Table 1).

Definition of Outcomes

The primary outcome of our study was the association of the eSAS with 30-day major morbidity. The secondary outcome measure was the association between the modified eSAS and 30-day major morbidity. Multivariable logistic regression analysis was used to determine the factors associated with major

Table 1. eSAS and Modified eSAS

Points	0	1	2	3	4
eSAS					
EBL (mL)*	>300	201–300	151–200	≤150	–
Lowest MAP (mm Hg)	<40	40–54	55–69	≥70	–
Lowest HR (beats/min)	>85	76–85	66–75	56–65	≤55
eSAS calculation formula					
EBL (mL)	>75th percentile	>Median–75th percentile	>25th percentile-median	≤25th percentile	–
Lowest MAP (mm Hg)	<40	40–54	55–69	≥70	–
Lowest HR (beats/min)	>85	76–85	66–75	56–65	≤55
modified eSAS					
EBL (mL)	>675	438–674	281–437	≤280	–
Lowest MAP (mm Hg)	<40	40–54	55–69	≥70	–
Lowest HR (beats/min)	>85	76–85	66–75	56–65	≤55

eSAS, esophagectomy surgical Apgar score; EBL, estimated blood loss; MAP, mean arterial pressure; HR, heart rate.
*Ranges of EBL in the original surgical Apgar score: >1000, 601–1000, 101–600, and ≤100 mL.

morbidity. In these analyses, we evaluated the patient's outcome as a dichotomous variable: either with or without complications. Therefore, if a patient with leakage developed sepsis as a result, this patient was assigned to the "with complications" category, and such patients were never double-counted by the type or number of complications.

With respect to major complications, and in accordance with the SAS[1] and eSAS[6] definitions, we adopted the following definitions of adverse events established by the National Surgical Quality Improvement Program (NSQIP): bleeding requiring at least 4 units of packed red blood cells within 72 hours of the operation, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep venous thrombosis, pulmonary embolism, coma for at least 24 hours, stroke, acute renal failure, wound disruption, deep or organ-space surgical site infection, systemic inflammatory response syndrome, sepsis, septic shock, pneumonia, unplanned intubation, and ventilator use for at least 48 hours.[11] Other complications not satisfying the NSQIP definitions were also regarded as major morbidities in our study if the complications met the Clavien-Dindo classification criteria.[12] Complications meeting the definition for Clavien class ≥III complications (requiring surgical, endoscopic, or radiologic intervention) were also considered major morbidities.

Statistical Analysis

Continuous variables are expressed as median (interquartile range), while categorical variables are expressed as number (percentage). The morbidity rates were compared between patient groups based on the cut-off value of the eSAS obtained using Fisher's exact test. The cut-off values of the eSAS and modified eSAS were determined by the area under the ROC. We determined the cut-off values using Youden's index.[13] The following confounding variables for morbidity, which were selected according to the medical implications, were forced into the statistical model: age, sex, body mass index (BMI), Charlson comorbidity index, smoking history, surgical approach, and history of chemoradiotherapy.[6–8] In the multivariable logistic regression analysis, adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. The fit of the models was assessed using the Hosmer-Lemeshow test. Statistical significance was set at $P < 0.05$, and all statistical analyses were performed using SAS version 9.4 for Windows (SAS Institute Inc., Cary, NC).

RESULTS

Patients

A total of 267 patients underwent elective esophagectomy at Shizuoka General Hospital during the study period. Patients who underwent resection for both esophageal cancer and another disease during the same surgical operation were excluded ($n = 19$). One patient with an implanted cardiac pacemaker and 1 who underwent resection for benign disease were also excluded. Therefore, 246 patients were included in the study. The characteristics of the enrolled patients are reported in Table 2.

Intraoperative Data

The patients' intraoperative data are shown in Table 3. Using these data, we calculated the eSAS as shown in Figure 1. We also reviewed the EBL to calculate the modified eSAS. The median EBL was 438 mL (range, 30−5585 mL; interquartile range, 281−675 mL), and we accordingly assigned points to every patient as follows: patients with EBL of >675, 438−674, 281−437, and ≤280 mL were assigned 0, 1, 2, and 3 points, respectively (Table 1).

Major Complications

Among the 246 patients, 144 (59%) had 1 or more morbidities (Table 4). In Table 4, the development of another complication in the same patient was counted as a separate complication (ie, double-counted). The most frequent complication was pneumonia (15%), and the next most frequent was sepsis defined by the systemic inflammatory response syndrome criteria (10%). Other complications included anastomotic stenosis, acute kidney injury, cholecystitis, recurrent laryngeal nerve palsy, lymphorrhea, and bronchial ulcer.

eSAS/Modified eSAS and Morbidity

The association between the eSAS/modified eSAS and morbidity is shown in Table 5. Using the ROC, the optimal cut-off value of the eSAS was 4 points (Youden's index = 0.069). When classified by this cut-off value, 145 patients had an eSAS of <4 points, and 89 of them developed morbidity. A total of 101 patients had an eSAS of ≥4 points, and 55 of them developed morbidity. Fisher's exact test was used to evaluate the association between the eSAS and morbidity, and the results indicated that the association was not statistically significant ($P = 0.29$).

After modification by EBL, the modified eSAS was calculated for all patients. ROC analysis showed that the optimal cut-off value of the modified eSAS was also 4 points (Youden's index = 0.180). When classified by this cut-off value, 79 patients had a modified eSAS of <4 points, and 57 of them developed morbidity. In contrast, 167 patients had a modified eSAS of ≥4 points, and 87 of them developed morbidity. Fisher's exact test showed that the modified eSAS was significantly associated with major morbidity ($P = 0.004$).

Multivariable Logistic Regression Analysis

After adjustment for potential confounders (including age, sex, BMI, Charlson comorbidity index, smoking history, surgical approach, and chemoradiotherapy history), no significant association was found between the eSAS and major morbidity (OR, 0.90; 95% CI, 0.51−1.59; $P = 0.72$; Table 6). In this analysis of the eSAS, only age was associated with morbidity (OR, 1.05; 95% CI, 1.01−1.08; $P = 0.009$). Conversely, in the analysis of the modified eSAS, which involved adjustment using the same confounding variables as for the eSAS, the modified eSAS (OR, 0.47; 95% CI, 0.25−0.85; $P = 0.013$) and age (OR, 1.04; 95% CI, 1.01−1.08; $P = 0.015$) were associated with major morbidity. The logistic regression models derived from the eSAS or modified

Table 2. Patient Characteristics and Their Associations With Morbidity

	All Patients ($N = 246$)	No Major Morbidity ($n = 102$)	Major Morbidity ($n = 144$)
Sex			
Male	221 (90)	91 (89)	130 (90)
Female	25 (10)	11 (11)	14 (10)
Age (y)			
<50	7 (3)	4 (4)	3 (2)
50–59	36 (15)	21 (21)	15 (10)
60–69	83 (34)	38 (37)	45 (31)
70–79	102 (41)	35 (34)	67 (47)
≥80	18 (7)	4 (4)	14 (10)
ASA class			
I	36 (15)	19 (19)	17 (12)
II	173 (70)	73 (72)	100 (69)
III	37 (15)	10 (10)	27 (19)
BMI (kg/m^2)			
<20.0	96 (39)	32 (31)	64 (44)
20.0–24.9	128 (52)	59 (58)	69 (48)
25.0–29.9	20 (8)	9 (9)	11 (8)
30–34.9	2 (1)	2 (2)	0 (0)
≥35.0	0 (0)	0 (0)	0 (0)
Smoking			
Current	30 (12)	10 (10)	20 (14)
Former	184 (75)	78 (76)	106 (74)
Never	32 (13)	14 (14)	18 (13)
Comorbid disease history			
Pulmonary	80 (33)	31 (30)	49 (34)
Cardiovascular	34 (14)	10 (10)	24 (17)
Chronic renal disease	47 (19)	13 (13)	34 (24)
Diabetes mellitus	28 (11)	15 (15)	13 (9)
Neoadjuvant CRT	152 (62)	62 (61)	90 (63)

Data are presented as *n* (%).
ASA, American Society of Anesthesiologists; BMI, body mass index; CRT, chemoradiation therapy.

Table 3. Intraoperative Data and Their Associations With Morbidity

	All Patients ($N = 246$)	No Major Morbidity ($n = 102$)	Major Morbidity ($n = 144$)
Surgical approach			
Open	63 (26)	24 (24)	39 (27)
Hybrid	79 (32)	30 (29)	49 (34)
MIE	104 (42)	48 (47)	56 (39)
Surgical technique			
Transthoracic	246 (100)	102 (100)	144 (100)
Transhiatal	0 (0)	0 (0)	0 (0)
Surgical time (min)	395 (355–436)	381 (344–423)	406 (360–446)
Anesthesia time (min)	473 (428–521)	460 (416–499)	479 (438–529)
EBL (mL)	438 (281–675)	345 (243–520)	550 (340–780)
Lowest MAP (mm Hg)	53 (48–56)	53 (48–57)	53 (48–56)
Lowest HR (beats/min)	65 (58–73)	65 (59–73)	65 (58–73)

Data are presented as *n* (%) or median (interquartile range).
EBL, estimated blood loss; HR, heart rate; MIE, minimally invasive esophagectomy; MAP, mean arterial pressure.

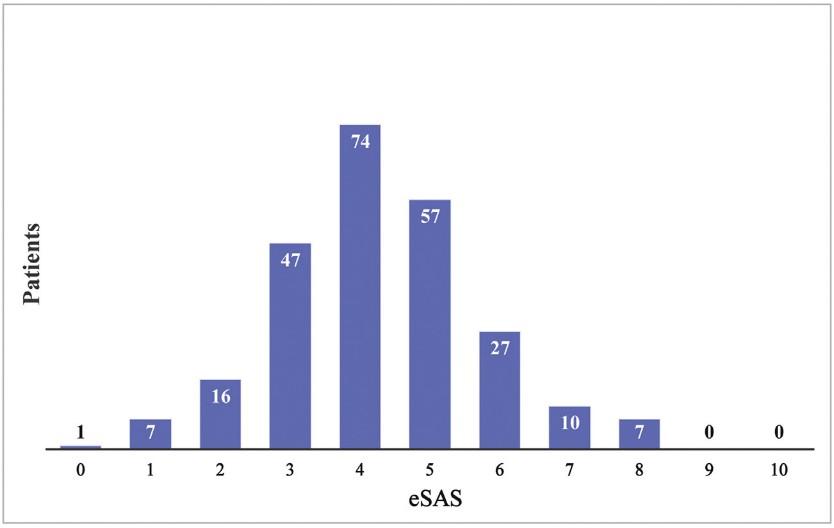


Figure 1. Distribution of all patients by esophagectomy surgical Apgar score.
eSAS, esophagectomy surgical Apgar score.

Table 4. Major Complications After Esophagectomy

All Patients (*N* = 246)	*n* (%)
All causes of death	5 (2)
Pneumonia	38 (15)
Sepsis (SIRS)	24 (10)
Anastomotic leakage	7 (3)
Unexpected transfusion	18 (7)
Pleural effusion	11 (4)
Surgical site infection	10 (4)
Other*	56 (23)

SIRS, systemic inflammatory response syndrome criteria.
*Other: anastomotic stenosis, acute kidney injury, cholecystitis, recurrent laryngeal nerve palsy, lymphorrhea, bronchial ulcer, etc.

Table 5. eSAS/Modified eSAS and Their Association With Morbidity

	n (%)	Morbidity *n* (%)	*P* Value
Patients	246 (100)	144 (59)	
eSAS			
<4	145 (59)	89 (61)	0.29
≥4	101 (41)	55 (54)	
Modified eSAS			
<4	79 (32)	57 (72)	0.004
≥4	167 (68)	87 (52)	

eSAS, esophagectomy surgical Apgar score.

Table 6. Multivariable Logistic Regression Analysis With Morbidity

	OR	95% CI	*P* Value
eSAS			
eSAS (≥4)	0.90	0.51–1.59	0.72
Age (1-y increments)	1.05	1.01–1.08	0.009
BMI	0.92	0.84–1.01	0.065
CCI	1.16	0.81–1.64	0.42
CRT history	0.95	0.53–1.73	0.87
Sex (male)	1.04	0.40–2.66	0.94
Smoking (ref: never)			
Former	1.01	0.46–2.24	0.98
Current	1.92	0.63–5.84	0.25
Surgical approach (ref: open)			
Hybrid	0.68	0.34–1.39	0.29
MIE	0.82	0.40–1.70	0.6
Modified eSAS			
Modified eSAS (≥4)	0.47	0.25–0.85	0.013
Age (1-y increments)	1.04	1.01–1.08	0.015
BMI	0.92	0.84–1.01	0.082
CCI	1.16	0.81–1.66	0.42
CRT history	0.89	0.49–1.62	0.7
Sex (male)	0.93	0.36–2.40	0.88
Smoking (ref: never)			
Former	1.02	0.46–2.30	0.96
Current	1.97	0.64–6.10	0.24
Surgical approach (ref: open)			
Hybrid	0.71	0.35–1.44	0.34
MIE	0.83	0.40–1.73	0.61

BMI, body mass index; CCI, Charlson comorbidity index; CI, confidence interval; CRT, chemoradiation therapy; eSAS, esophagectomy surgical Apgar score; MIE, minimally invasive esophagectomy; OR, odds ratio.

eSAS for morbidity exhibited good predictive ability (Hosmer-Lemeshow test, $P = 0.60$ and $P = 0.97$, respectively).

DISCUSSION

This study investigated the validity of the eSAS in our hospital database. We demonstrated that an eSAS with an optimal calculated cut-off point may not be associated with 30-day major morbidity after esophagectomy. In addition, we found that the modified eSAS based on the original eSAS calculation formula is promising for prognostic prediction. The additional multivariable analysis revealed that the only factors associated with 30-day major morbidity were the modified eSAS and age. The above results indicate that the estimated blood loss should be reviewed again in the future (Fig. 2, Graphical Abstract).

In 2015, Janowak et al[6] recalculated the EBL (1 of the 3 factors used to calculate the SAS) and proposed the eSAS. However, they calculated the eSAS using a stepwise method, which is not currently recommended statistically. In addition, esophageal cancer is treated using different surgical techniques in each country, and the transhiatal technique (performed in 29% of cases in their study) is never performed at our hospital (Table 3). These findings indicate that the eSAS is not a universally available score worldwide, and we firmly believe that the eSAS should be reassessed.

We retrospectively investigated 246 patients in the present study. Several previous studies of the eSAS have also been reported. Stroyer et al[8] retrospectively analyzed 234 cases of esophageal cancer surgery and found that the SAS, eSAS, and modified eSAS (calculated by the same method used in the present study) could not predict the prognosis. However, the most promising score among the 3 was the modified eSAS (OR, 0.84; 95% CI, 0.68–1.03). Xing et al[7] reported that the eSAS with a 7-point cut-off was useful for predicting postoperative complications (OR, 2.81; 95% CI, 1.11–7.14). Although Xing et al[7] evaluated the eSAS, this score was not the same eSAS that Janowak et al[6] advocated because they changed the EBL so that it was adapted to the actual condition of their facility. Based on these findings, the predictive value of the eSAS was denied in 3 studies, including ours; however, the modified eSAS with re-correction of the EBL is likely to be promising. Eto et al[14] reported that the SAS with a 5-point cut-off is useful in esophagectomy (OR, 2.88; 95% CI, 1.69–4.97). Thus, a review the eSAS concept itself seems necessary.

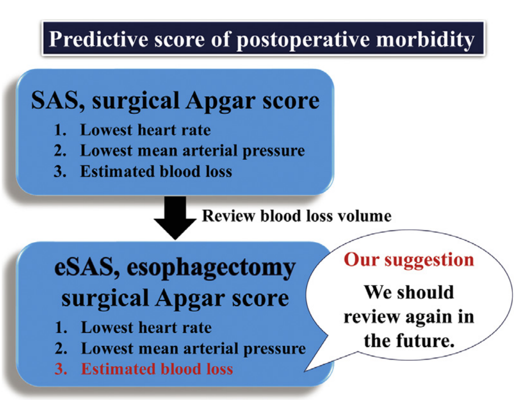


Figure 2. Suggestion from this study.
From the SAS, the eSAS is a score which changed thresholds of estimated blood loss values. The eSAS with an optimal calculated cut-off point may not be associated with major morbidity; in contrast, the modified eSAS is a promising indicator of the estimated blood loss. These results were supported by the additional multivariable analysis. These results indicate that the estimated blood loss should be reviewed again in the future.

Although the difference between the eSAS and modified eSAS is use of the EBL, EBL measurement during surgery remains controversial. In a past study, the highly experienced staff did not accomplish accurate measurement of the EBL, and the estimated error was large.[15] In our hospital, the volume of drainage during surgery is also included in the EBL, thus increasing the measured amount of bleeding. As discussed above, the EBL has a large degree of error and differs depending on the practice of each facility or individual. Although the original SAS also uses the EBL, we believe that this problem is associated with the SAS itself.

The definition of morbidity is also controversial. Because we focused on validation of the eSAS, we adopted the NSQIP definition and Clavien-Dindo grade ≥III definition to fully match the article by Janowak et al[6] In contrast, other eSAS validation studies adopted only the Clavien-Dindo classification.[7,8] This causes obvious differences in study findings. For example, transfusion of 4 units of packed red blood cells was counted as morbidity in our study, but not in the Clavien-Dindo classification (Table 4). If we do not standardize this definition of morbidity, accurate assessment of the eSAS will be difficult.

To evaluate the robustness of this study, we conducted an additional analysis using only the widely accepted definition of a Clavien-Dindo grade ≥III complication as a serious complication according to a validated system; we excluded the NSQIP definition. Most of the items were duplicated; the major difference was whether 4 units of packed red blood cells were included, as described above. An additional analysis was performed with the exclusion of transfusions. There was no association between the eSAS and morbidity; however, the modified eSAS was associated with morbidity ($P = 0.19$ and 0.004, respectively; Supplemental Table 1). We do not believe that the results of this study were affected by the definition of morbidity.

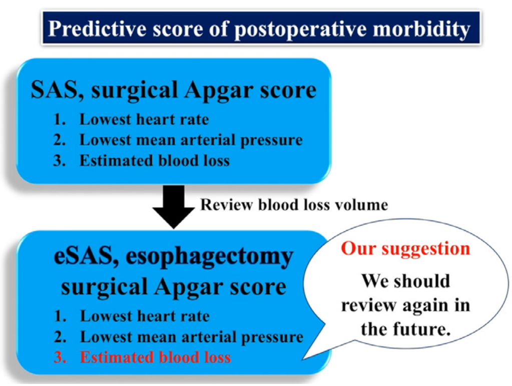
Our multivariable analysis showed that the only factors related to morbidity were age and the modified eSAS. In a past multivariable analysis, a forced expiratory volume of ≤78% and eSAS of ≤7 were considered predictive factors for morbidity.[7] We presume that this difference is associated with the fact that ideal statistical models were not obtained because of the small sample size of each study. As a strength of our research, we would like to emphasize that biostatistics specialists participated from the start of the research plan and independently took charge of the statistical analysis.

We acknowledge that this cohort study has some limitations. First, it was conducted in a single institution and had a relatively small sample size. However, compared with other eSAS validation studies, we ensured that the patient inclusion criteria and definition of complications were consistent with a previous study of the eSAS.[6] It is reasonable to state that our study provides valuable information. Second, many patients sustain a very low blood pressure for short periods of time during esophagectomy. Because the esophagectomy in the present study included a mediastinal procedure that is expected to cause blood pressure fluctuation, the influence of this fluctuation may have been greater than that induced by other types of surgery.

In conclusion, this study demonstrated that the eSAS was not associated with 30-day morbidity after esophagectomy. However, the modified eSAS, which involves regulation of the EBL, may be useful. Further research on this topic is desired.

SUPPLEMENTARY MATERIAL

The following is the supplementary data to this article:



Video 1. The authors explain why the eSAS should be reviewed. BMI, body mass index; CCI, Charlson comorbidity index; CI, confidence interval; CRT, chemoradiation therapy; eSAS, esophagectomy surgical Apgar score; MIE, minimally invasive esophagectomy; OR, odds ratio.

REFERENCES

1. Gawande AA, Kwaan MR, Regenbogen SE, et al: An Apgar score for surgery. J Am Coll Surg 204:201–208, 2007
2. Prasad SM, Ferreria M, Berry AM, et al: Surgical Apgar outcome score: Perioperative risk assessment for radical cystectomy. J Urol 181:1046–1052, 2009
3. Zighelboim I, Kizer N, Taylor NP, et al: Surgical Apgar score predicts postoperative complications after cytoreduction for advanced ovarian cancer. Gynecol Oncol 116:370–373, 2010
4. Wuerz TH, Regenbogen SE, Ehrenfeld JM, et al: The surgical Apgar score in hip and knee arthroplasty. Clin Orthop Relat Res 469:1119–1126, 2011
5. Urrutia J, Valdes M, Zamora T, et al: An assessment of the surgical Apgar score in spine surgery. Spine J 15:105–109, 2015
6. Janowak CF, Blasberg JD, Taylor L, et al: The surgical Apgar score in esophagectomy. J Thorac Cardiovasc Surg 150:806–812, 2015
7. Xing XZ, Wang HJ, Qu SN, et al: The value of esophagectomy surgical Apgar score (eSAS) in predicting the risk of major morbidity after open esophagectomy. J Thorac Dis 8:1780–1787, 2016
8. Stroyer S, Mantoni T, Svendsen LB: Evaluation of the surgical Apgar score in patients undergoing Ivor-Lewis esophagectomy. J Surg Oncol 115:186–191, 2017
9. von Elm E, Altman DG, Egger M, et al: The strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. J Clin Epidemiol 61:344–349, 2008
10. Regenbogen SE, Ehrenfeld JM, Lipsitz SR, et al: Utility of the surgical Apgar score: Validation in 4119 patients. Arch Surg 144:30–36, 2009.. discussion 37
11. Khuri SF, Daley J, Henderson W, et al: The National Veterans Administration Surgical Risk Study: Risk adjustment for the comparative assessment of the quality of surgical care. J Am Coll Surg 180:519–531, 1995
12. Dindo D, Demartines N, Clavien PA: Classification of surgical complications; a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240:205–213, 2004
13. Kumar R, Indrayan A: Receiver operating characteristic (ROC) curve for medical researchers. Indian Pediatr 48:277–287, 2011
14. Eto K, Yoshida N, Iwatsuki M, et al: Surgical Apgar score predicted postoperative morbidity after esophagectomy for esophageal cancer. World J Surg 40:1145–1151, 2016
15. Rothermel LD, Lipman JM: Estimation of blood loss is inaccurate and unreliable. Surgery 160:946–953, 2016